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Social Computing: Fundamentals and Applications

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(Extended Abstract)

From ancient abacuses to modern computers, our desire for more power in computing and drive for its deep application seem endless. First we saw the emergence of scientific computing after ENIAC six decades ago, and then the tide of bio- and medical informatics in 1980s. Today, the wave of virtual worlds and the real force inside the Web have pushed us beyond the physical space to a new direction in computing: Social Computing.

I. What is Social Computing?

What is social computing? In a sense, it is a new field with a long history. As shown in Figure 1, there have been two schools of thoughts in this area. The first one takes an information-technology centric approach, considers basically social computing as social software, and focuses at applying the knowledge from social studies to design and improve the efficiency and performance of software such as email, Internet, and other computer-supported collaborative works (CSCW). This is still the mainstream of social computing and its origin can be traced back to the beginning of modern computing, from Vannevar Bush's ***Memex*** in his landmark paper "*As We May Think*", Douglas Engelbart's ***NLS*** (oNLine System) and his vision in his bible "*Augmenting Human Intellect: A Conceptual Framework*" that "integrate psychology and organizational development with all of these advances in computing technology", to J.C.R. Licklider's ***Man-Computer Symbiosis*** where computers were emphasized as devices of communication, not machines of computing. Note that all three are considered as true pioneers of Internet with contribution consisting of mainly ideas not inventions. Although no words of "social computing" or "social software" were used explicitly in their works, their ideas reflect its true character and real content. To me, current social software and related studies, although already extremely powerful and sophisticated, are still primitive prototypes of those pioneers' vision so many years back in history.

Figure 1: Two Schools of Thoughts: From Social Software to Social Computing

The second school is more social-sciences centric and relatively new. Closely related to the emerging new discipline of Web Sciences [1], it emphasizes on utilizing information technology to design and evaluate cyber-physical systems, to study and manage social behaviors and corresponding organizational dynamics, especially those in virtual worlds built with the Internet. Although term "social computing" was not mentioned, two recent events in our history and their subsequent studies have played a critical role in pushing this new direction to the front. The first event is the dramatic political reform in the former eastern European communist countries in the beginning of 1990s, where TV and fax, primitive and simple, became important devices in shaping societal dynamics "on line" and in "real time", and inspired RAND researchers to propose "artificial societies" as a concept for basic research on the societal impacts of information technology and claim that "the most important policymaking over the next several decades will occur at the intersections of the information technologies and social change"[2]. The second is 9/11 event in 2001 and subsequent terrorist attacks in other parts of the world, where the Internet and mobile communication have played a vital role in their planning and execution, also in the way, speed as well as scale they impact people and societies afterward. This has motivated AI researchers at the University of Arizona to initiate a new study of Intelligence and Security Informatics (ISI) that employs methods and tools developed in bio- and medical informatics for security issues ranging from international to personal and political to economic [3].

Since a comprehensive evaluation of the state of the art of social computing can be found in [4-5], here our focus is on its research from the perspective of social sciences. Thus by social computing we mainly imply computational theories and methods for human and social studies, or more specifically, for social activities, social processes, and social organizations. However, unlike the first school of thoughts on social computing and computational sociology from social sciences, we emphasize at the intersections of the information technologies and social studies, especially their forms on the Web.

II. WHY SOCIAL COMPUTING NOW?

Far and most, the Internet is the original motivation for and the natural consequence of social computing. At this point, we can still consider cyberspaces as virtual spaces or virtual worlds, but very soon it will no longer "virtual", it will be as real as our traditional physical spaces or real worlds, and consist of 50%, no more no less, of our living space or our world. Furthermore, just like we need modern physics to deal with high speeds of rockets and lights, and extreme scales from cosmos to quarks, we must have a new science for social studies in the age of integrated cyber- and physical worlds, where information spreads in the speed of light and reaches every corner in no time, organizations involving tens of thousands people are created over nights or even over minutes, and any individual who is able to click might have an equal or even bigger voice than a powerful government. In a sense, the cyberspace has facilitated, if not instigated, a fundamental shift in political power in human societies, which can be exploited for both good and bad causes. The new science for social studies, where social computing will play a significant role, must be able to face those new situations and challenges. This is the reason we need social computing now.

Many works have been done along this direction in both information and social sciences. However, here we call for a paradigm shift in the research of social computing by adapting the three-stage approach of modeling, analysis, and control that has been effectively and successfully used for solving many problems in natural and engineering sciences, as discussed in sequel.

III. MODELING WITH ARTIFICIAL SOCIETIES

So far there have been no effective and widely accepted methods for modeling complex systems, especially for those involving human behaviors and social organizations, as in the case of social computing. Up to this point, agent-based artificial societies or general artificial systems might be the most promising attempt toward a unified approach for modeling problems of such complexity and diversity. There are three major parts in modeling with artificial societies: agents, environments, and rules for interactions. Note that when modeling with artificial societies for complex systems in social computing, the accuracy of approximation to real systems to be modeled is no longer the only objective as for traditional computer simulations. Instead, "model society" represented by an artificial system is considered as a "reality", an alternative and another possible realization of real target society. Along this line of thinking, the real society is also one of the possible realizations. Therefore, the behaviors of two societies, real and artificial, although different, are considered to be "equivalent" for the purpose of evaluation and analysis. This is the basis for thinking and reasoning when modeling and analyzing complex social computing problems with artificial societies.

Of course, modeling with artificial systems does not exclude the exact description of target systems. Actually, approximation with high accuracy is still the desired goal for many applications whenever that is achievable. The idea of "equivalent" behaviors is a forced compromise due to some intrinsic limits and constraints when dealing with complex systems.

IV. ANALYSIS BY COMPUTATIONAL EXPERIMENTS

Traditionally, passive observations and statistical methods are often used in social studies since it is difficulty to conduct active tests and evaluations, let alone repeatable experiments. Even when experiments are permissible, there might be too many subjective, uncontrollable and unobservable factors involved in the process so that the validity and use of the corresponding results and conclusions are limited. Since very few problems in social computing can be solved by analytical reasoning, finding an effective way of conducting experiments becomes a key and critical step for further development of social computing research.

Modeling with artificial societies provides a promising new mechanism for experiments in social computing: using artificial societies, we can treat computers as "social laboratories", design and conduct controllable and observable "experiments" in an easily manipulable and repeatable fashion, then evaluate and analyze quantitatively various effecting factors in social computing problems. This is the idea of *computational experiments*, a natural extension and systematic utilization of computer simulation techniques [6]. With computational experiments, a traditional social simulation becomes an experimental process in a "computer social lab". Like experiment design in the physical world, for design of computational experiments, we must deal with basic issues related to calibration, analysis, and verification, and follow design principles such as replication, randomization, and blocking.

Several important issues need to be addressed before computational experiments can be effectively and widely used for analysis of social computing problems. For example, sampling and interview with agents, adoption of Gallup Poll techniques, temporal-spatial distributions in virtual worlds, etc.

V. Control and Management through Parallel Execution

By parallel execution we mean running parallel systems consisting of a real system and one or more corresponding artificial systems in parallel. The parallel execution, considered as a generalization of conventional industrial controllers used in automaton that use analytical models of target physical processes to drive those targets to the desired states, provides a new mechanism for control and management of complex social systems, especially those in cyber-physical settings [7]. The operational principle of parallel execution is based on managing complex systems through comparing, testing, evaluating, predicating, interacting, and controlling a real system and multiple artificial systems in parallel and simultaneously. As outlined in Figure 2, there are three major modes of operations for parallel execution, namely, 1) learning and training, where real and artificial systems are normally disconnected; 2) experimenting and evaluating, where the connection among parallel systems are on and off alternatively; and 3) controlling and managing, where artificial systems try to emulate the real system such that their behaviors can be used to improve and optimize the perform of the actual process in real time. Note that methods and algorithms developed in simulation-based optimization and adaptive control, such as rolling horizon analysis and model reference feedback control, could be very useful in parallel execution.

The concept of Parallel Management Systems (PMS) or management based on parallel execution was originally proposed and used for complex social-engineering systems, such as transportation systems, electrical power grids, ecosystems, and social economic systems [8-9]. Due to the nature of fast dynamics and extreme scale in cyber-physical systems, PMS can be a preferred approach for conducting and implementing social computing on the Web.

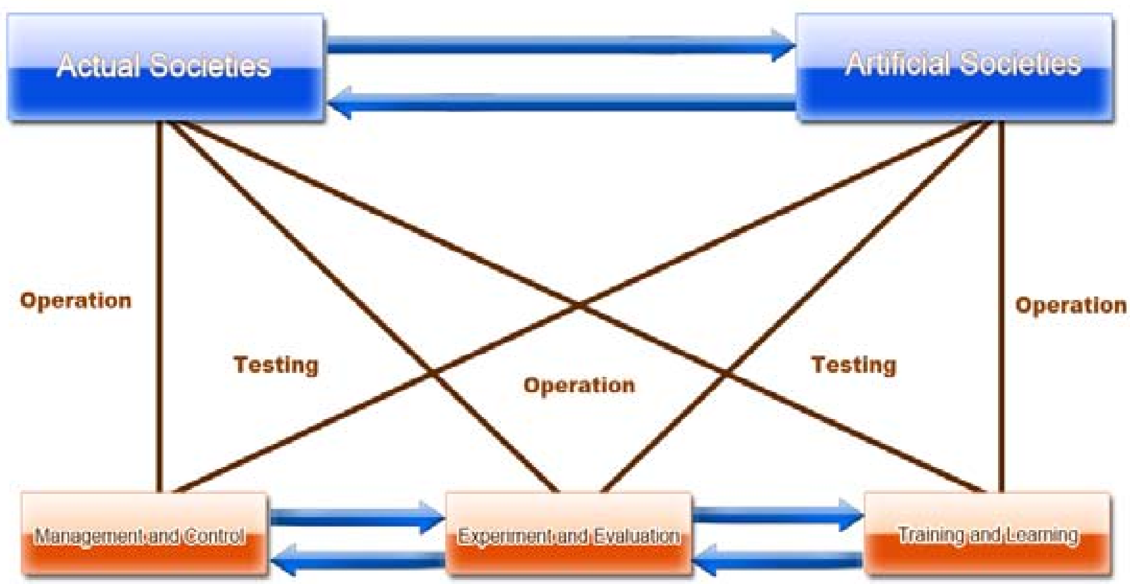

Figure 2: Parallel Execution for Control and Management in Social Computing

VI. The Foundation: From Philosophy to Physics

The call for such a paradigm shift would lead social computing into unknown territories of artificial entities, and many may question the existence of any scientific values in conducting research with virtual worlds. However, as illustrated in Figure 3, some fundamental thought and theories in philosophy and physics could provide logical and disciplinary foundations for works along this direction [4].

Karl Popper, one of the greatest philosophers in modern times, has proposed a three-world model of knowledge: world 1 the physical world of knowledge, world 2 the mental world, and world 3 the expressed or stated world of knowledge where artifacts are chosen by humankind to represent knowledge and trigger further room for thought and reflections. World 3, the world of artifacts or the artificial world, are divided further into three parts: world 3.1 for objects in world 1, world 3.2 for world 2, and world 3.3 for artifacts unknown to both world 1 and world 2. Social physics, introduced by Harvard linguist George Zipf, can be considered as one of early attempts to establish physical laws as we know of in world 1 for world 3. Furthermore, our parallel systems can also be viewed as a "practical utilization" of the many-worlds interpretation envisioned by Huge Everett for quantum mechanics 50 years ago. Relationship between those concepts and social computing based artificial societies could be an interesting topic for further investigation.

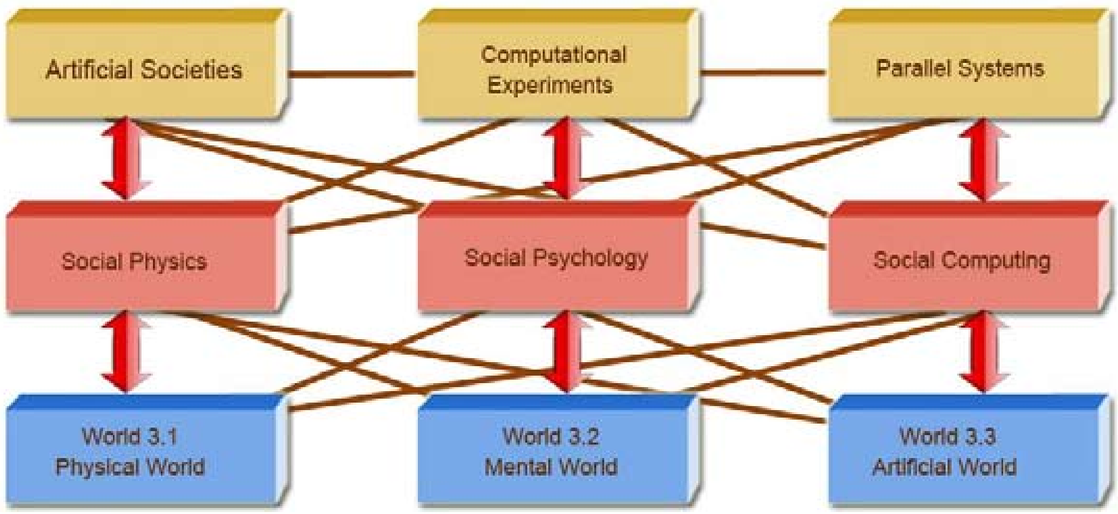

Figure 3: Logical and Disciplinary Foundations for Social Computing: From Philosophy to Physics

In conclusion, social computing is an exciting new direction in computing and a field for both researchers in information and social sciences. Over the past two decades, social software, from email to blog, has fundamentally changed our ways of living, working, and interacting with each others. Could research efforts in social computing inspire some revolutionary changes in our way of conducting and using social studies in the coming decades? We have high hopes. As pointed out by American sociologist George Lunderg in 1939: "It may be that the next great developments in the social sciences will come not from professional social scientists, but from people trained in other fields".

VII. References

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Biography: Dr. Fei-Yue Wang is Professor, Systems and Industrial Engineering, at The University of Arizona in Tucson, Arizona, USA. He is presently on leave from The University of Arizona and serves as the vice president of the Institute of Automation at The Chinese Academy of Sciences in Beijing, People's Republic of China. Professor Wang obtained the Ph.D. in Computer and Systems Engineering from Rensselaer Polytechnic University in 1990. His research interests lie in applied technologies (ASIC, SOC, SOPC, ASOS, RT OS, Embedded Systems, Agent-Based Distributed Systems) as well as various application areas (ITS, IV, GPS, Telematics, Web Caching, Smart Appliance and Home Systems). His research interests encompass mathematical theory of intelligence machines, robotics and automation, as well as design and control of manufacturing systems.